

Coordinate Measuring Machine and Programmable Calculator

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Quality Assurance Mechanical Inspection, anticipating the need for improved measuring techniques for the various Laboratory programs, has purchased a Coordinate Measuring Machine which has the capability of significantly reducing inspection time while increasing reliability.

I. Introduction

It was necessary for JPL Quality Assurance to find improved methods of performing inspections with speed and reliability. Commercially available equipment would have to meet the following criteria:

- (1) Expand measurement capabilities.
- (2) Reduce set-up time (man-hours).
- (3) Increase speed and accuracy.
- (4) Have English (inch)/metric display and printout capabilities.

The Coordinate Measuring Machine, equipped with a programmable calculator, expands measuring capabilities and, in place of time-consuming manual recording and calculations, instantly computes and prints out measurements.

II. Description of Equipment

The Coordinate Measuring Machine (Fig. 1) is a three-axis X,Y,Z measuring device. Each axis is provided with bronze air bearings which allow all measuring axes a frictionless noncontact movement, assuring a deflection-free measurement.

The measuring system employs a principle of reading fluctuations of light intensities through photocells. These photocells pick up the changes in intensities which are 90 deg out of phase. Then, through electronic circuitry, these measurements are digitally displayed in either English or metric.

A feature of the machine is the touch trigger probe. This probe is an omnidirectional electronic null-sensing device with a repeatability of 1.0 μm (0.00005 in.) and feather-touch sensitivity of 0.04 N (4 g). The touch trigger probe, for example, with a contact point having a right angle bend, could be used to check in any direction the

depth and height of internal grooves or bores having stepped diameters.

The programmable calculator (Fig. 2) is the heart of the Coordinate Measuring Machine and uses a pre-programmed cartridge tape to perform operations previously requiring the use of a computer. It has a 12-digit readout display and a hard copy printer which permanently records all measurements.

A choice of measuring systems (Cartesian or Polar) is provided, and single-point or multipoint measuring methods (Fig. 3) may be programmed. The Cartesian System is for determining the location of a point in relation to two straight lines. This is frequently used in box-type rectangular dimensioning. The Polar Coordinate System determines the location of a point in relation to its radius vector from a fixed origin. Polar coordinates are frequently used for measuring bolt holes and circles.

The single-point method is for measuring the center distance between patterns with a tapered probe or a ball probe, or for measuring along the edge of a part. Multipoint methods are used for measuring hole diameters and determining the center by measuring points on the wall of the hole with a ball probe. All desired information is provided by the calculator.

An important feature is automatic alignment, which compensates for misalignment between the workpiece on the measuring table and the measurement axes by calculating a correction factor and applying that factor to the measurements taken.

Specifications

Resolution: 0.002 mm or 0.0001 in.

Measurement accuracy: ± 0.012 mm or ± 0.0005 in.

Repeatability: ± 0.005 mm or ± 0.0002 in.

Work table: Solid black granite with stainless steel thread inserts

Bearings: Frictionless air bearings (open adjustable type)

Measuring range: X 685 mm or 27 in.; Y 508 mm or 20 in.; Z 457 mm or 18 in.

III. Previous Test Methods Versus Coordinate Measuring Machine

Previously used methods of inspecting hardware were generally confined to the use of height gages, dial indicators, and depth gages. These instruments were used to measure such parameters as roundness, flatness, true position, etc. The hand method of measurements is slow and subject to human error.

The Coordinate Measuring Machine can be programmed to handle parameters of true position, roundness, and flatness. The following are examples of calculator measurement programs:

Example 1 (Fig. 4) illustrates a program which measures the center in polar coordinates and the diameter of holes and bosses using the multipoint method with ball probe which permits use of automatic alignment. Measurements are taken in any of three planes, with a printout of radius angle, diameter of holes, and X, Y dimensions.

Example 2 (Fig. 5) illustrates a program which measures the concentricity of two features, with the second feature taken at maximum material condition (MMC). The multipoint method using a ball probe for measurements and deviations is expressed as a diameter or total indicator reading (TIR). The printout shows concentricity limit as a tolerance, with deviations of out-of-tolerance conditions.

Example 3 (Fig. 6) illustrates a program which measures the roundness of a feature, holes or bosses, and inside or outside radii, using the multipoint method.

Example 4 (Fig. 7) illustrates a program which measures true position regardless of feature size, using the Cartesian Coordinate System. If the diameter being measured does not lie within the prescribed diameter tolerance, the closer deviation limit is used in the true position calculation.

Example 5 (Fig. 8) illustrates a program which measures a pattern generation. This program, having axis starting point and axis spacing with the offset angle along each axis, is all that is required to generate a rectangular or circular pattern.

IV. Summary

When dealing with a number of parts having many critical tolerances, the hand method is very time-consuming, and very often costly attachments are needed to perform the inspection required. By using the Coordinate Measuring Machine with calculator and touch trigger probe, hardware is inspected quickly and accurately, with all measurements automatically printed out for a complete record of dimensions.

This machine is definitely cost-effective and reduces Quality Assurance costs in the following ways:

- (1) It increases inspection productivity by a factor of three to one (as compared to the conventional surface plate, height gage, and indicator method).
- (2) Its use requires no special tooling (eliminates the cost of jigs and fixtures).
- (3) It eliminates human error. Problems that are inherent in transcribing data manually are nonexistent and thus inspection down time is reduced.

Bibliography

Validator 50 Manual, Brown & Sharpe Manufacturing Co., North Kingstown, R. I., June 15, 1974.

"Computer Capabilities," Fact Sheet Val-CC, Brown & Sharpe, North Kingstown, R. I.

"Val-Calculator," by Textronix, Fact Sheet Val-Cal, Brown & Sharpe, North Kingstown, R. I.

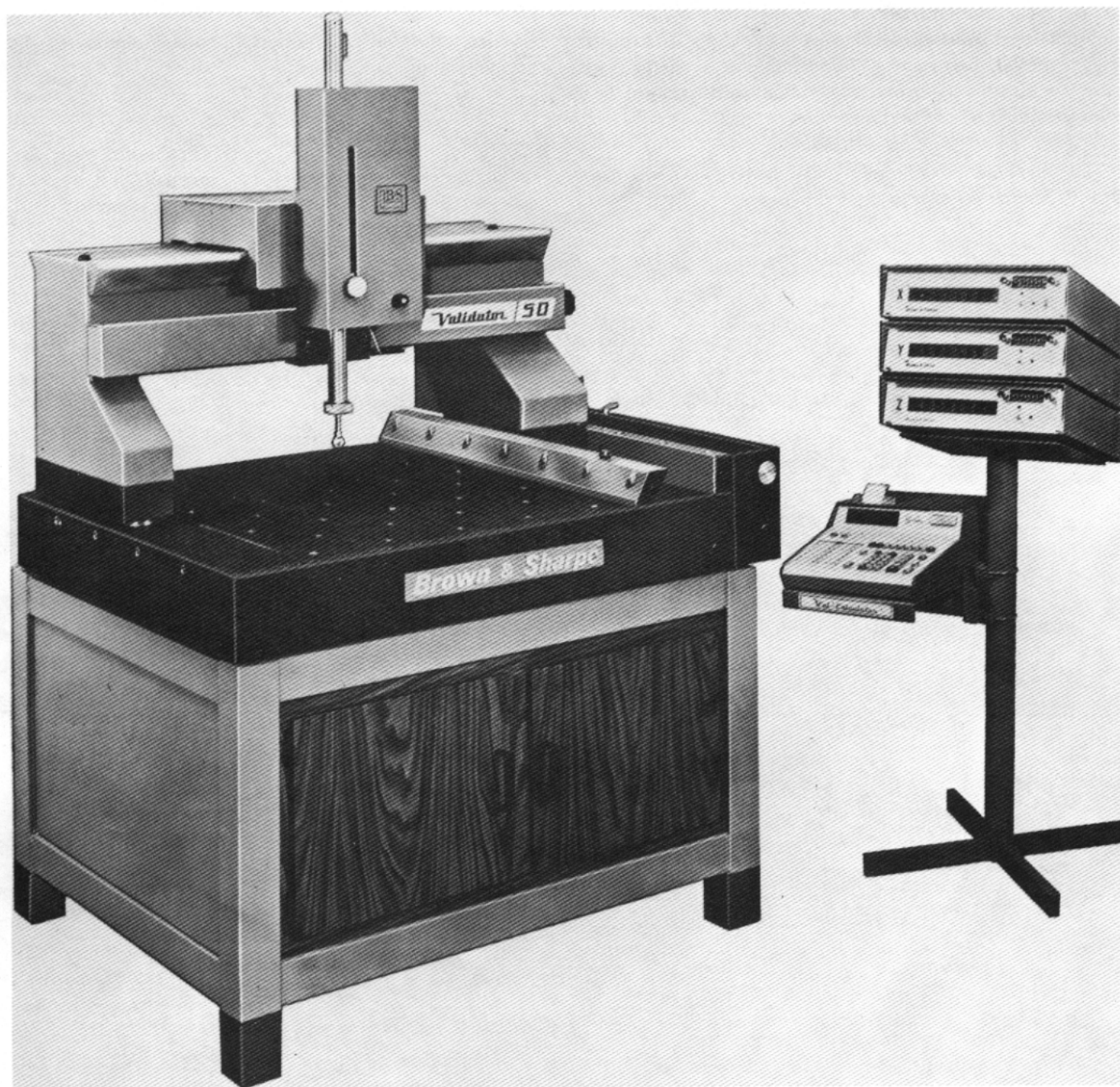


Fig. 1. Coordinate measuring system

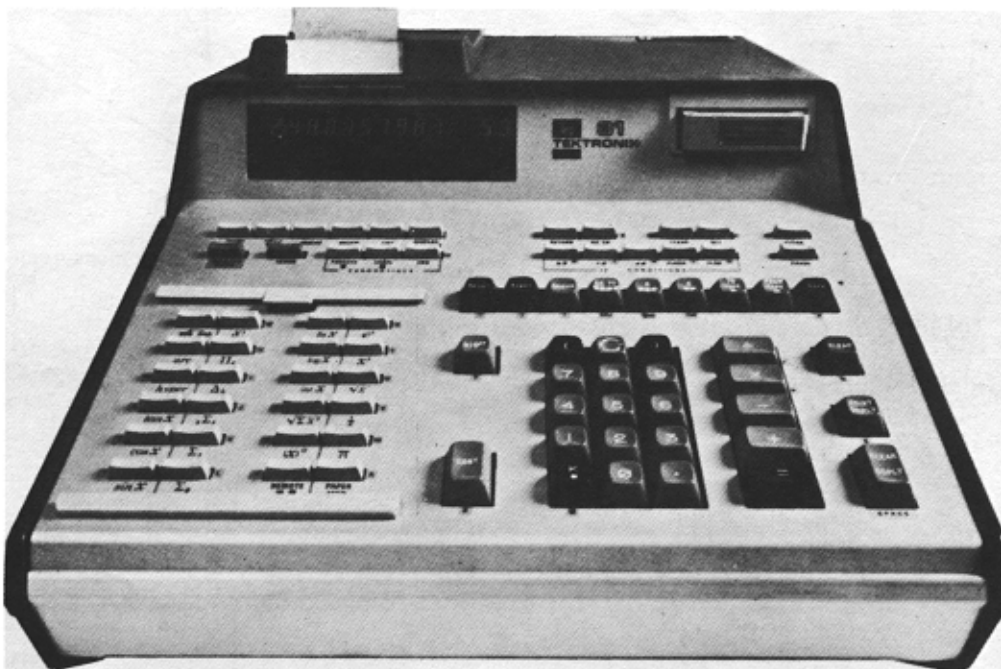


Fig. 2. Programmable Val-Calculator

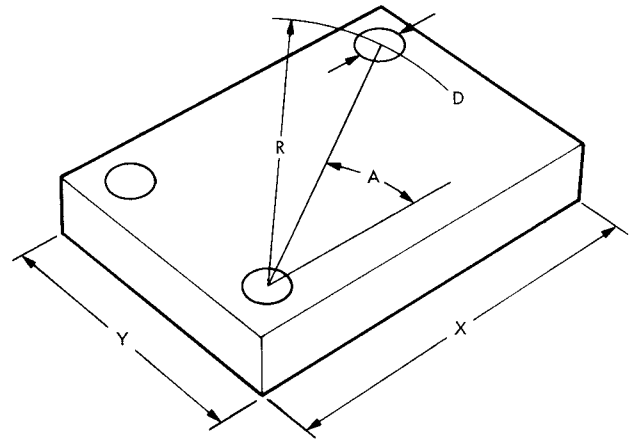
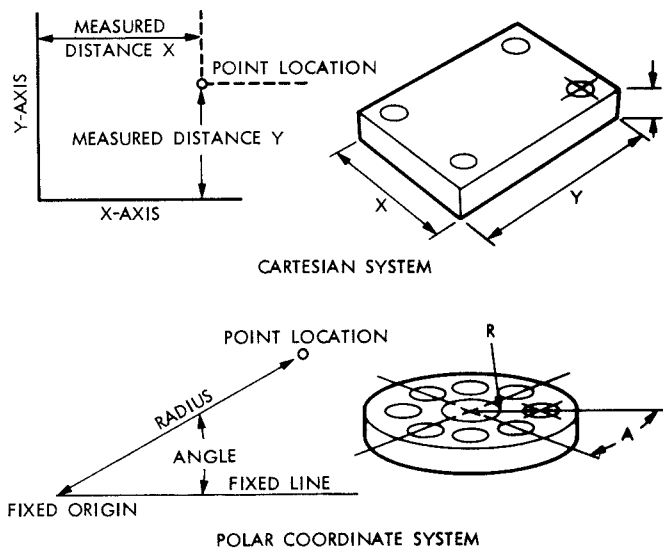


Fig. 4. Three-plane measurement

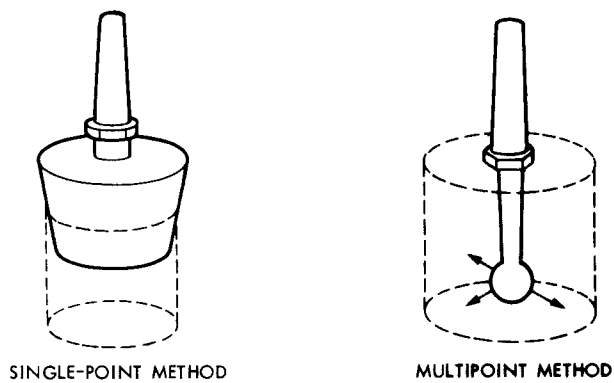


Fig. 3. Single-point and multipoint measuring methods

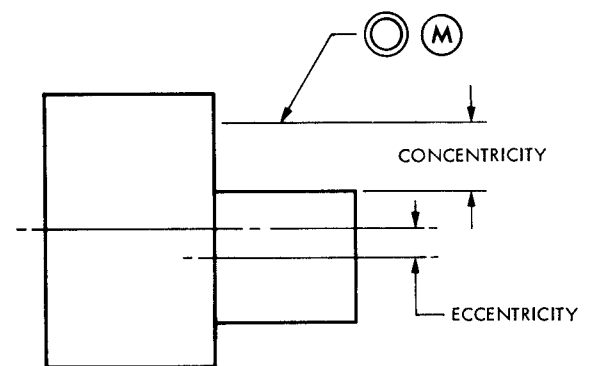


Fig. 5. Concentricity measurement

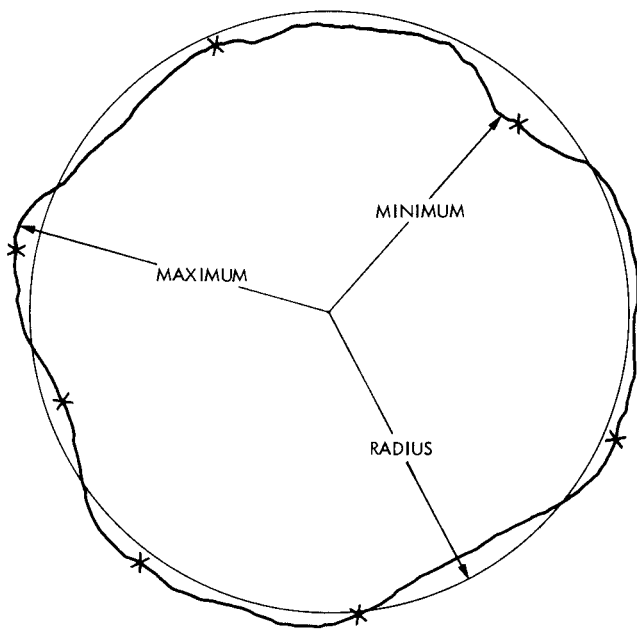


Fig. 6. Roundness measurement

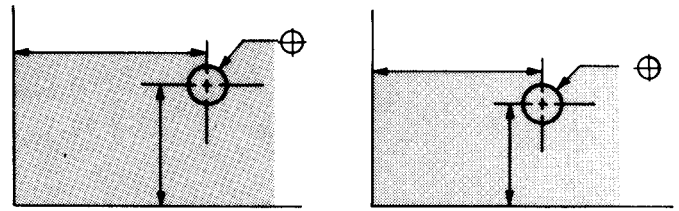


Fig. 7. True position measurement

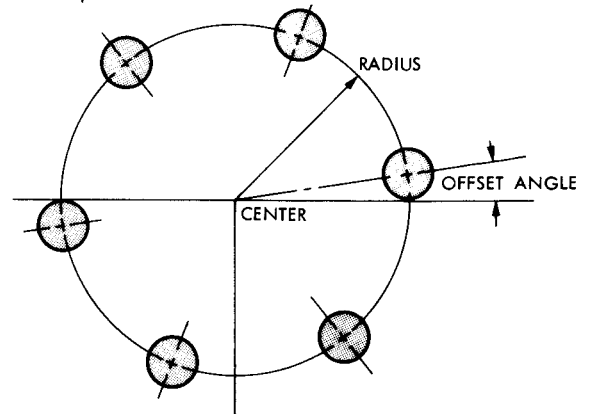
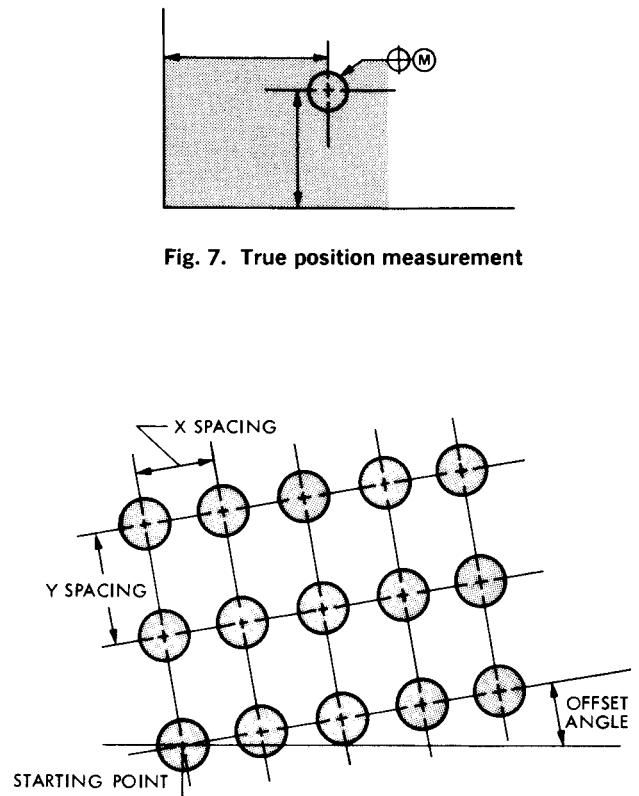


Fig. 8. Pattern generation measurement